Renewables in power markets

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Renewables in power markets

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Content:

Background – Renewables: Why is fluctuating/intermittent generation an issue in Denmark

Power markets

- Short term marginal costs
- Day ahead power markets
- Average prices
- Price volatility
- Renewable generator revenues
- Interaction with other technologies

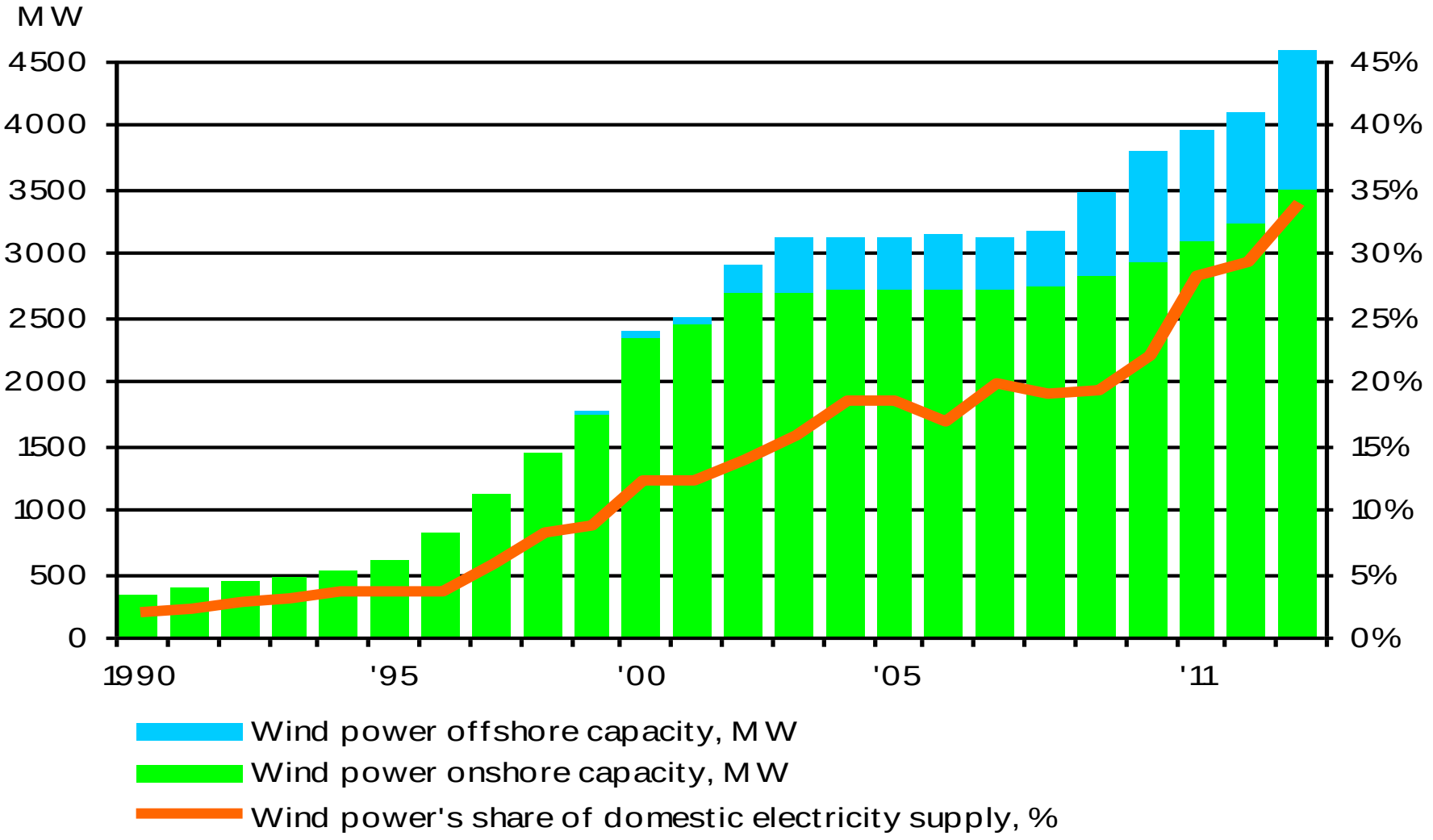
Long term effects on markets and investment incentives

- Support distort the market investment signals?
- The challenge: Does lower market price mean that more capacity is **not** needed?

A price curiosity?

- Negative prices - yes - can be providing correct incentives (solution) for short term dispatch
- A challenge that renewables receive production support

Development of wind power in Denmark and its effect on power prices



Background – Why is fluctuating renewable generation an issue in Denmark

Power markets: should provide correct signals to both producers and consumers - efficient allocation of generation among producers and investment in the system-wise least cost technologies

Renewables:

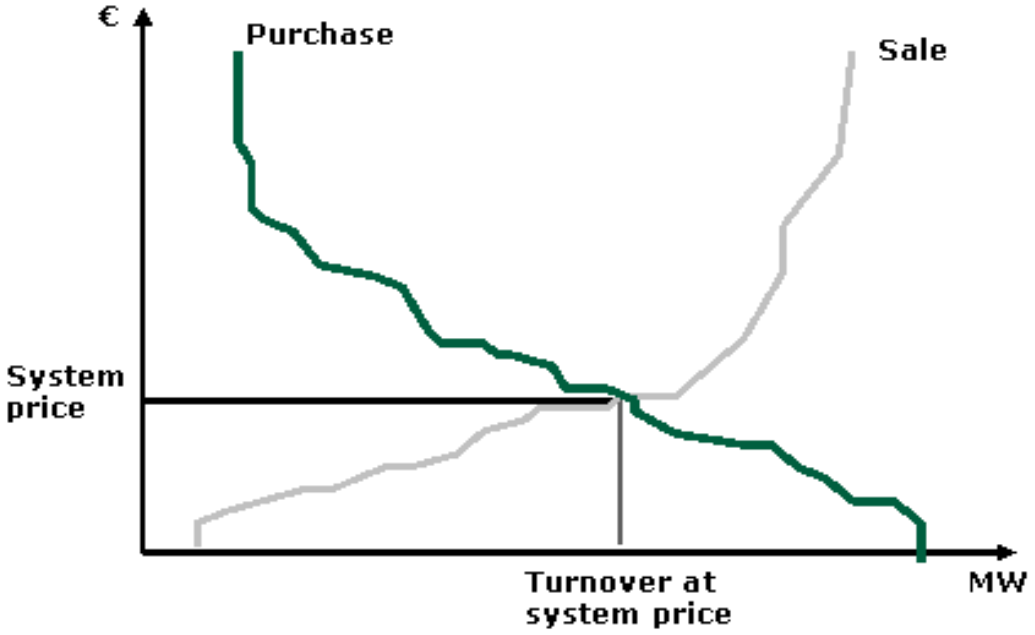
- Characterised by low variable and high fixed costs (wind, PV, Wawe, CSP etc)
- Day ahead power markets with hourly bids in common market, (uncertainty)
- Renewables supported by primarily production based support (feed-in tarifs or premiums)
- Average prices affected by adding capacity (short term)
- Price volatility - affected
- Renewable generator (market)revenues lower than average generater
- Interaction with other technologies - depends on system characteristics
- Support distort the market investment signals?

Denmark have a politically agreed target for reaching a fossil fuel free energy consumption in the year 2050

Wind energy is relatively cheap and will be a main contributor to this development
Target for 2020 is 50% of total electricity

Electricity markets: standard supply and demand

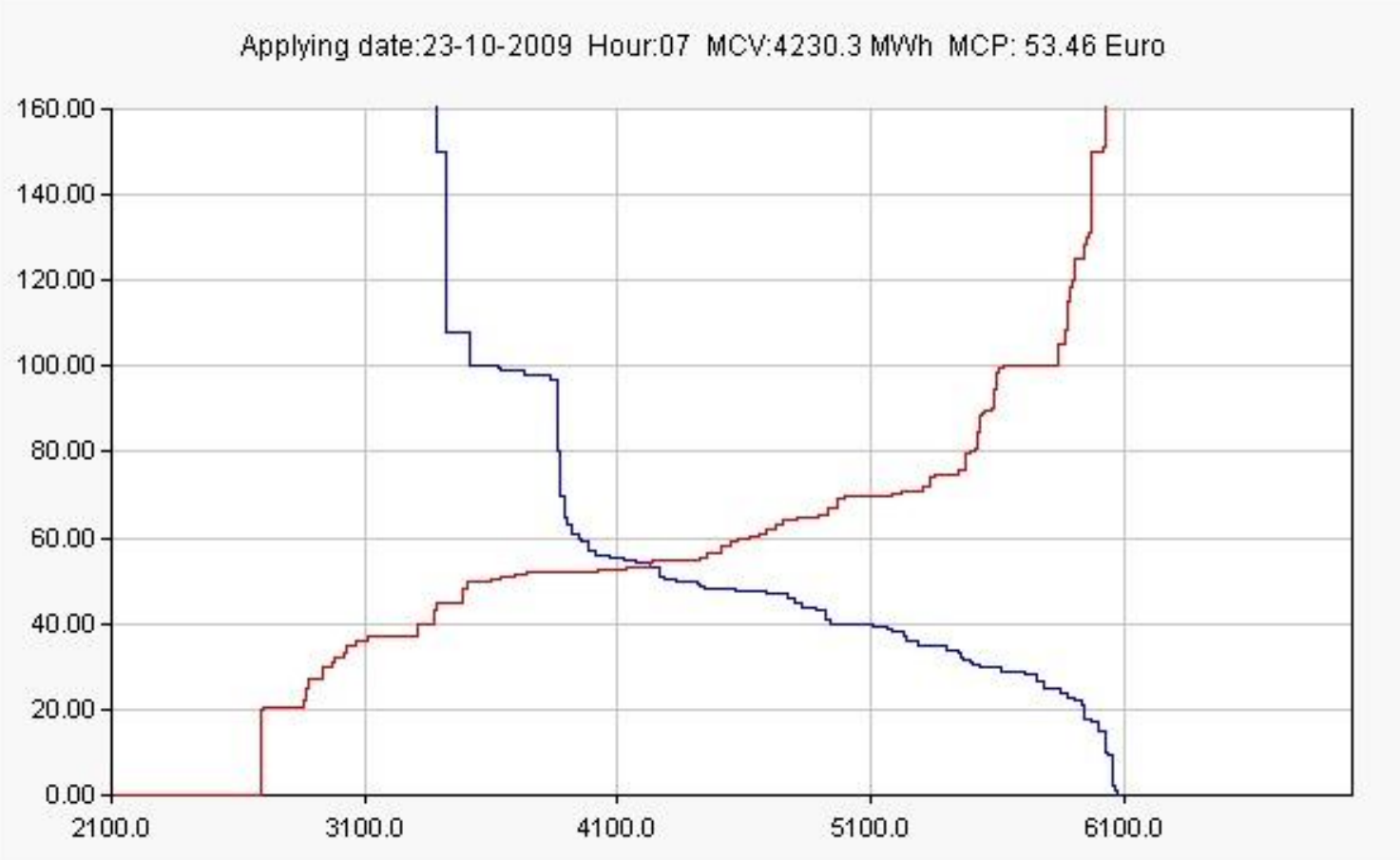
- Day ahead markets: 24 periods of 1 hour from 12 midnight the same day to 12 midnight the following day
- Buyers and sellers bid *stepped curves* based on their short term marginal costs
- A marketplace clears the market at 12 noon and instruct generators to follow the corresponding generation plan the following day - area prices dependent on transmission constraints



Nordpool homepage/NASDAQ

AGGREGATED CURVES

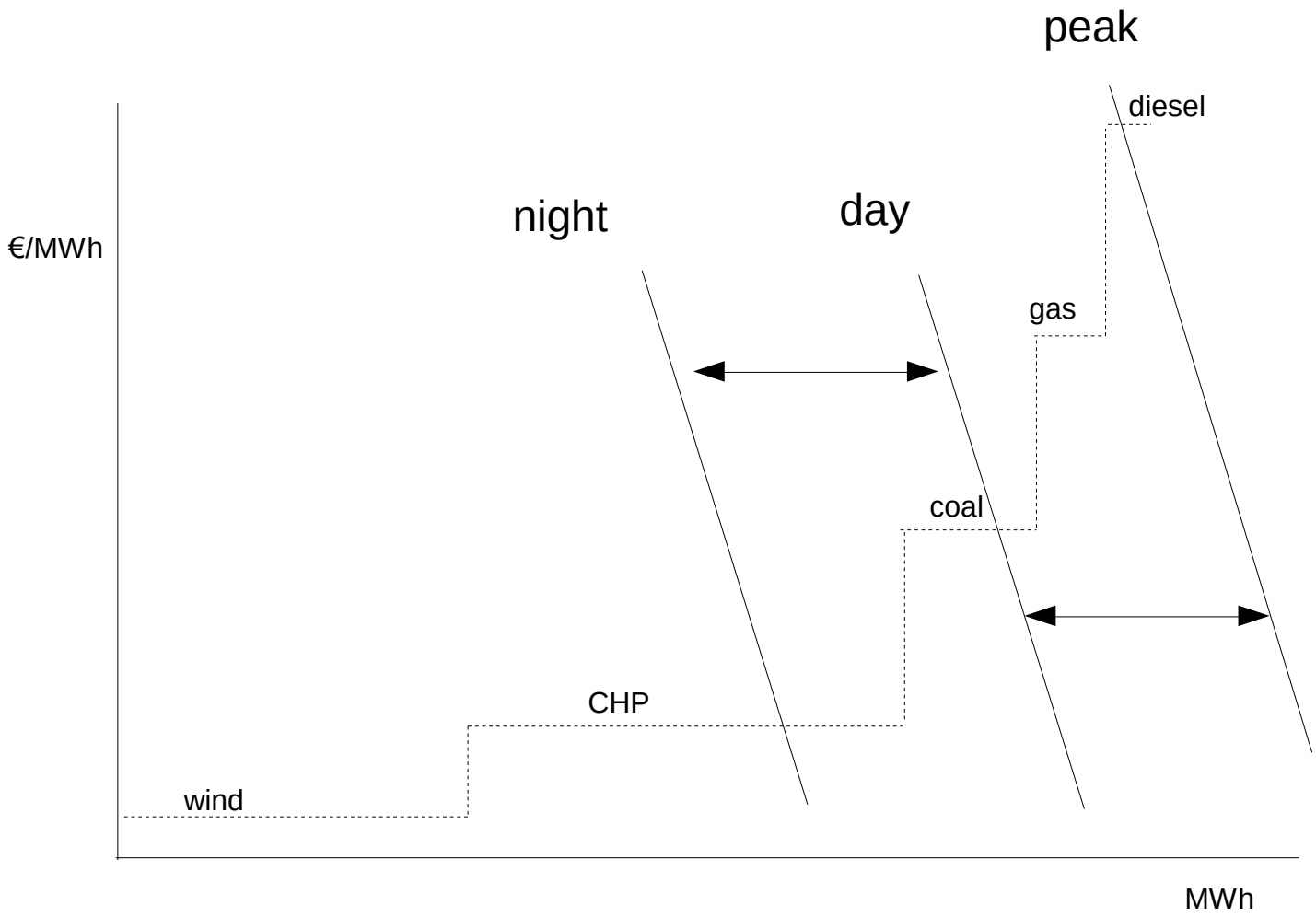
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 Zoom



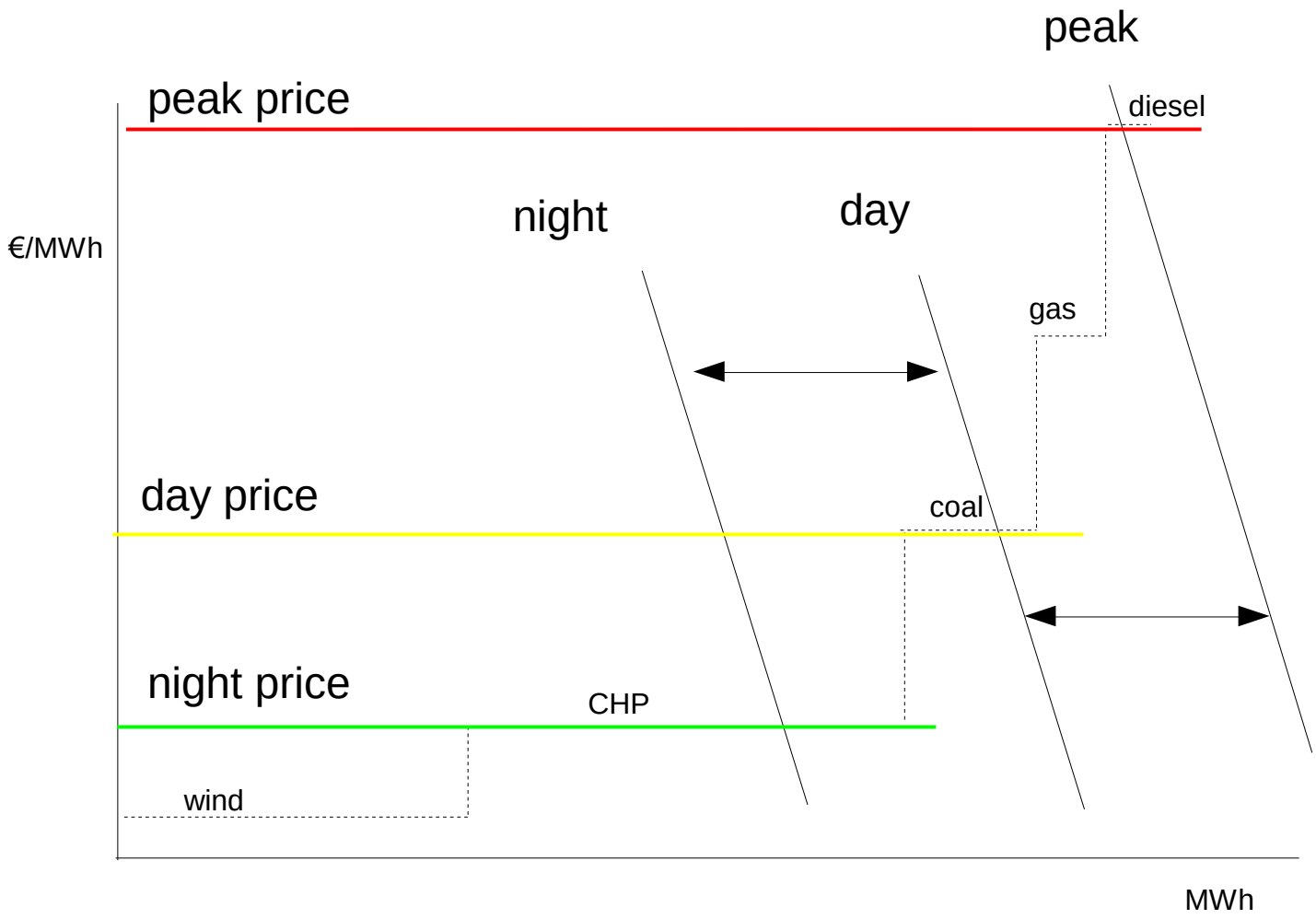
Short term marginal costs determine power price

- The supply curve in day ahead market is reflecting the short term marginal costs - mainly the fuel costs per MWh supplied
- Generation technologies differ with regard to the mix of variable and fixed costs (and joint production in case of CHP)
- Fluctuating renewable generation forms the *lower left part of the supply curve*
- Variation in generation from renewables will thus shift the entire supply curve
- Demand is *price* inelastic in the short term

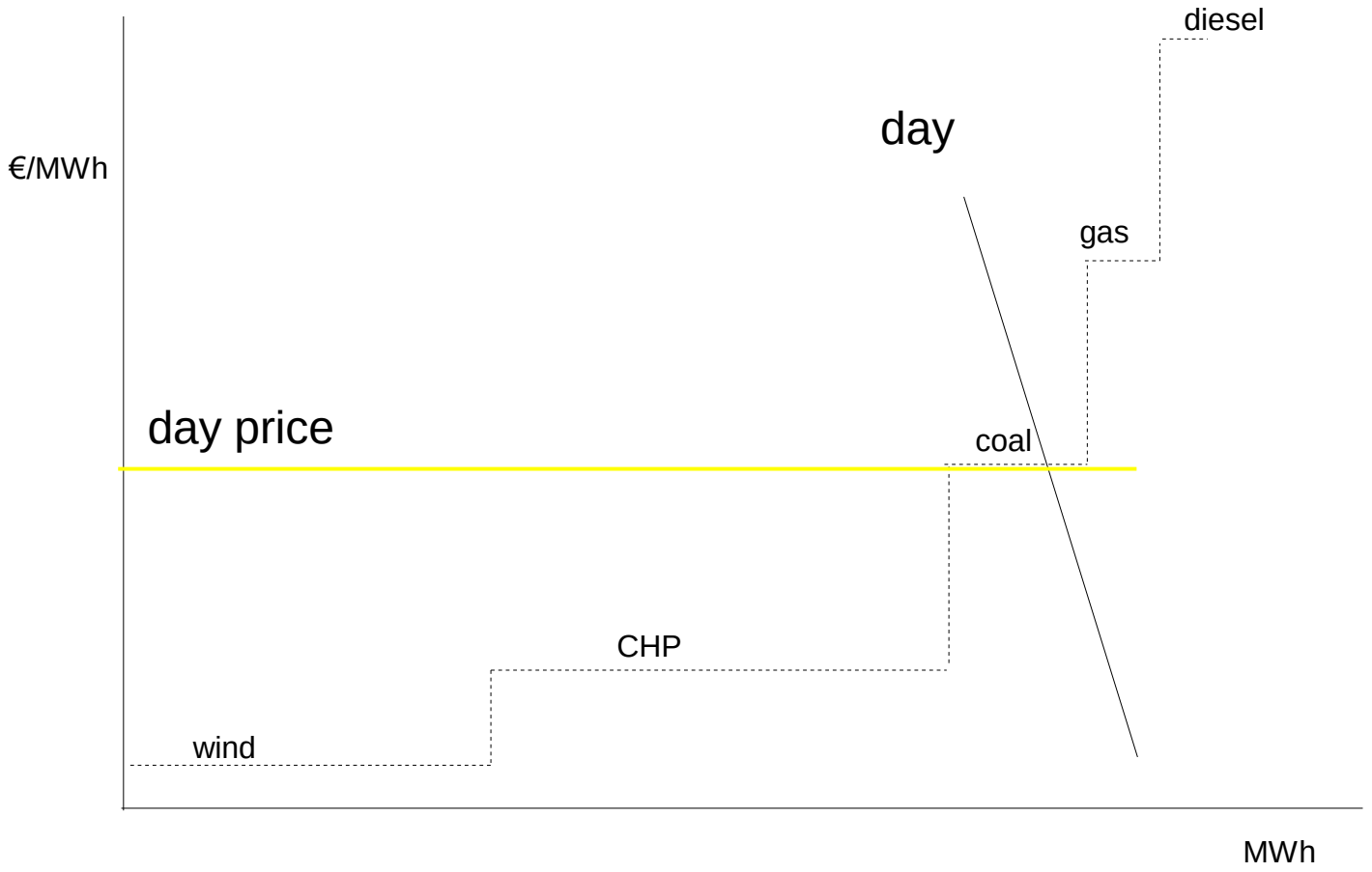
Electricity Prices



Electricity Prices



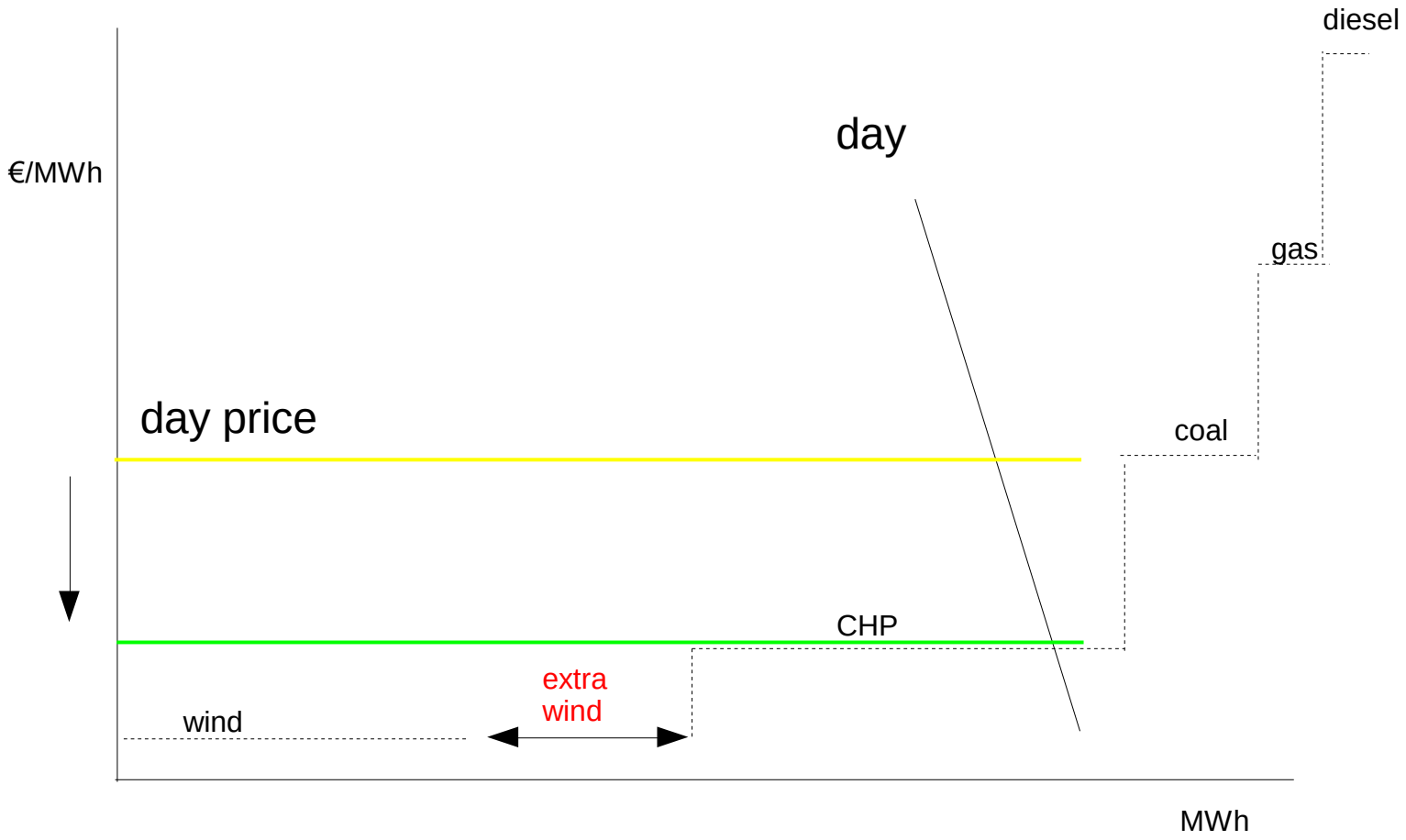
Electricity Prices

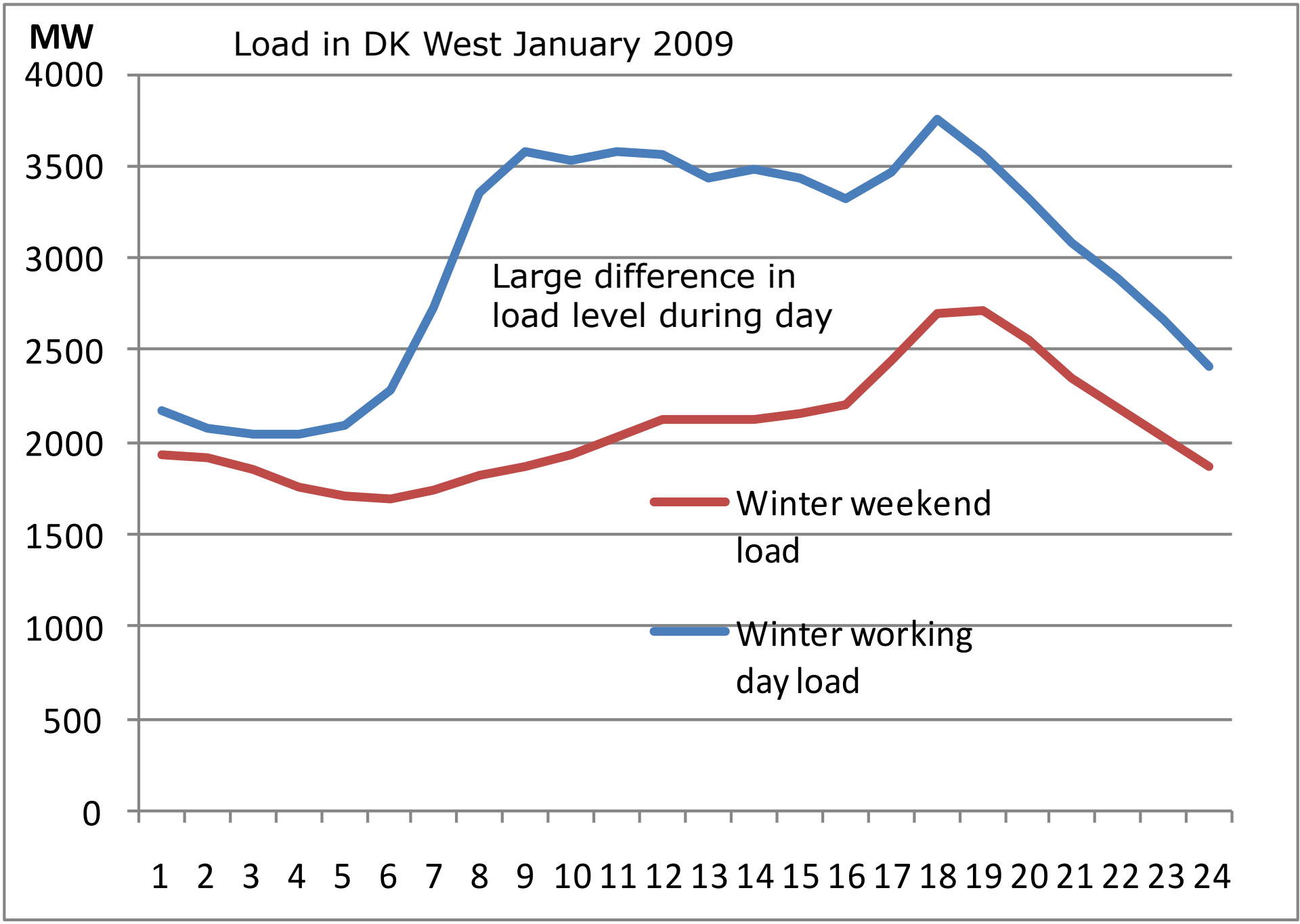


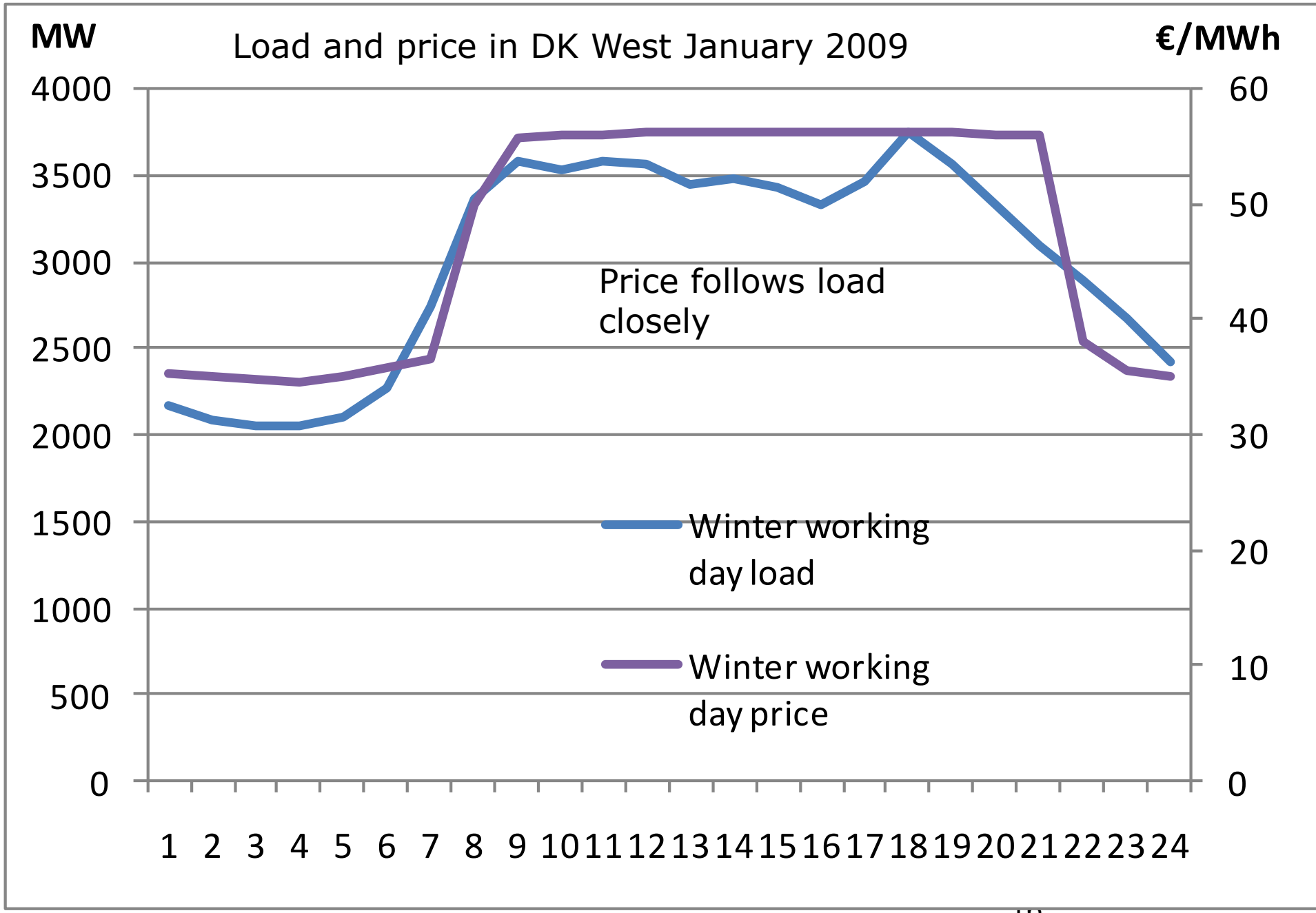
Adding renewable capacity and the short term price effect

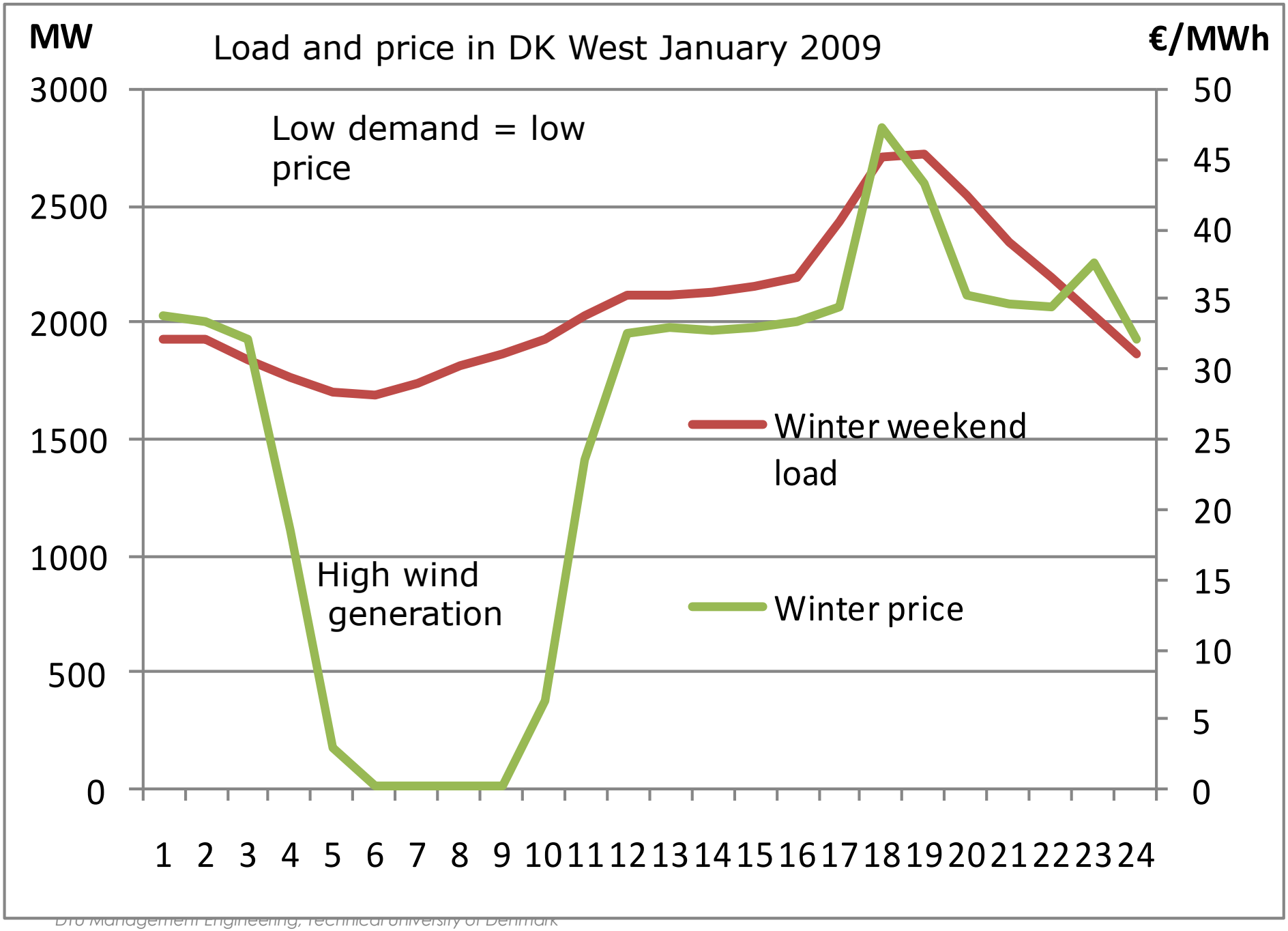
- Average wholesale power price is reduced
- Price is reduced the most when demand is high (peak load) and the least when demand is low
- Other generation with low variable cost(base load technologies) would also shift the supply curve to the right. (nuclear)
- The relative effect for the consumer price is much less, since the network costs, the renewable support and all the taxes are added to the wholesale price
- The wholesale market does not provide the investment incentives to renewable generators - this is provided outside the market

Electricity Prices




MW
Load in DK West January 2009
4000
3500
3000
2500
2000
1500
1000
500
0
Large difference in load level during day
Winter weekend load
Winter working day load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


MW
Load and price in DK West January 2009
€/MWh
4000
3500
3000
2500
2000
1500
1000
500
0
60
50
40
30
20
10
0
Price follows load closely
Winter working day load
Winter working day price
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

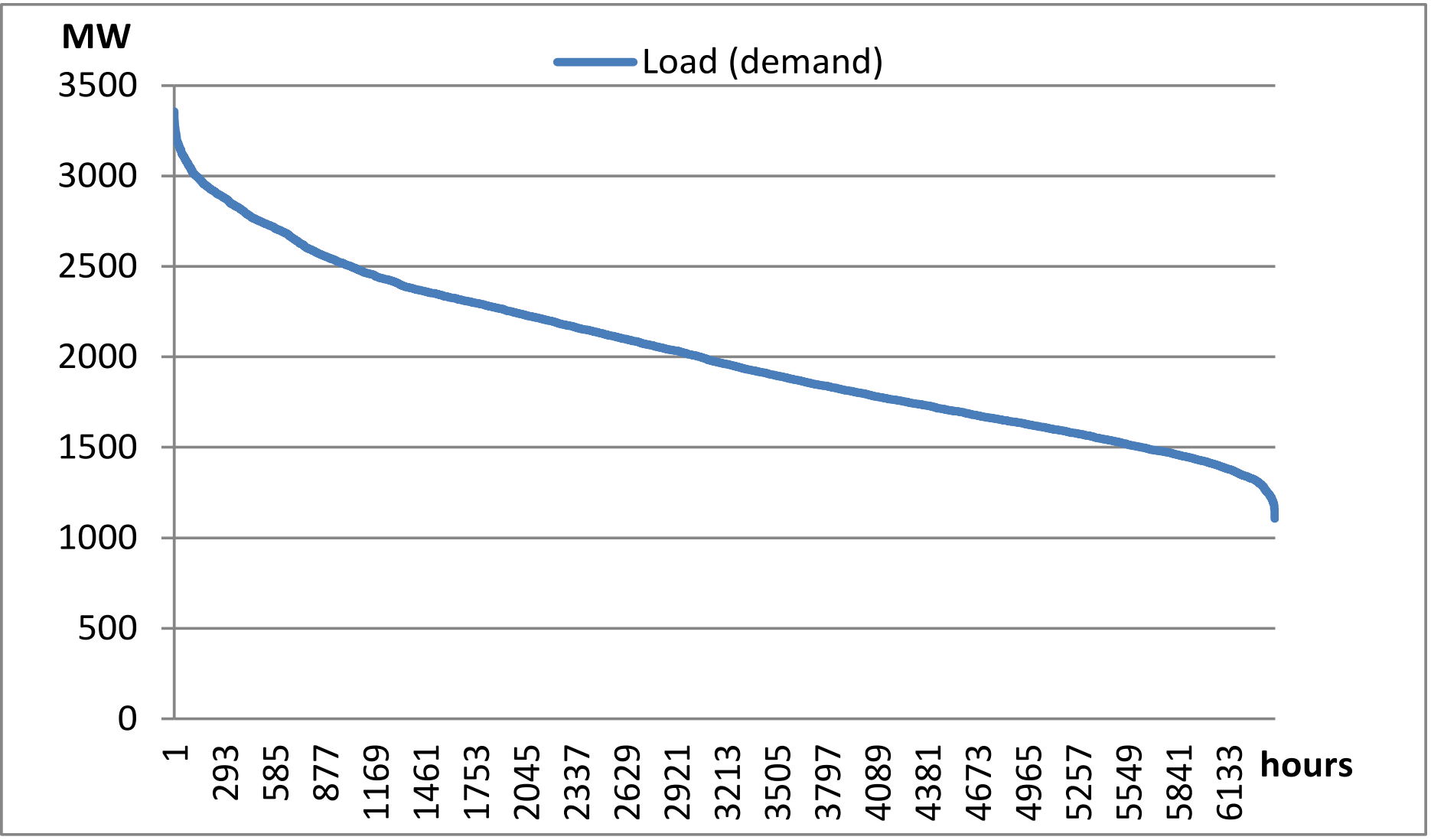

MW
Load and price in DK West January 2009
€/MWh
3000
2500
2000
1500
1000
500
0
50
45
40
35
30
25
20
15
10
5
0
Low demand = low price
High wind generation
Winter weekend load
Winter price
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Price effect and volatility effect depends on demand variation and composition of power system

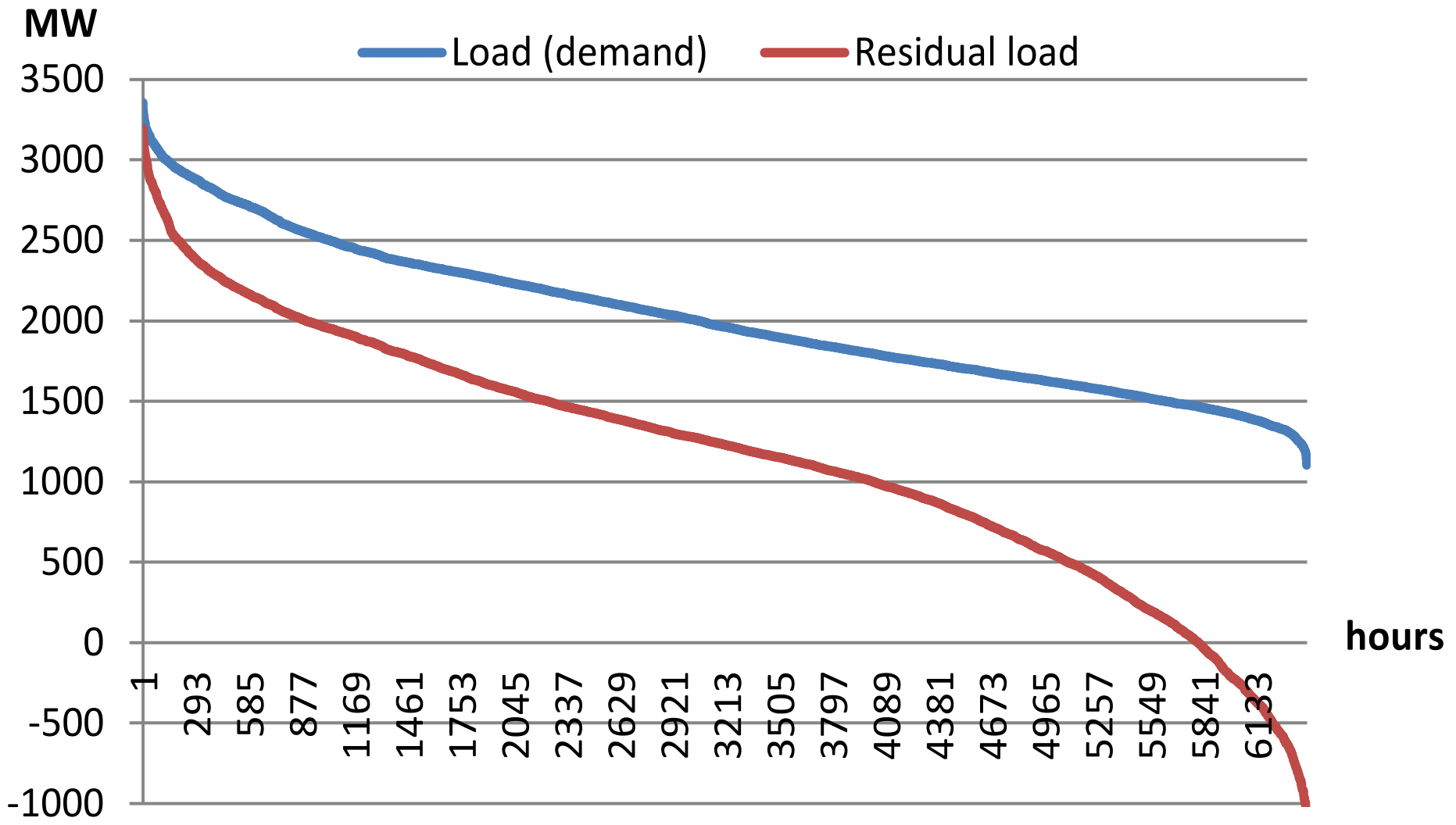
- Intermittent generation will affect prices most in systems with few flexible generation resources – nuclear, baseload coal etc.
- Intermittent generation will affect prices most if demand variation is large
- Price effect is high if short term demand flexibility (elasticity) is low

The price effect and the volume effect has an impact on all generation technologies

Load duration curve Denmark West January-September 2013



Subtracting the wind generation Denmark West January-September 2013



Electricity price and renewable generator revenues

- Renewable generators receive support
  - feed-in tariffs
  - premiums
  - green certificates
  - investment grants or tax credits

So why does prices matter for renewables?

- First
  - premiums create some market dependence
  - green certificates imply high market price dependence
  - feed-in given as fixed term (15 years) support and afterwards 100% market!
- Secondly
  - Most utilities portfolios include intermittent generation and conventional generation
  - Investment in intermittent generation will influence the revenue of the entire portfolio of generation technologies

Annual revenue effects for generators

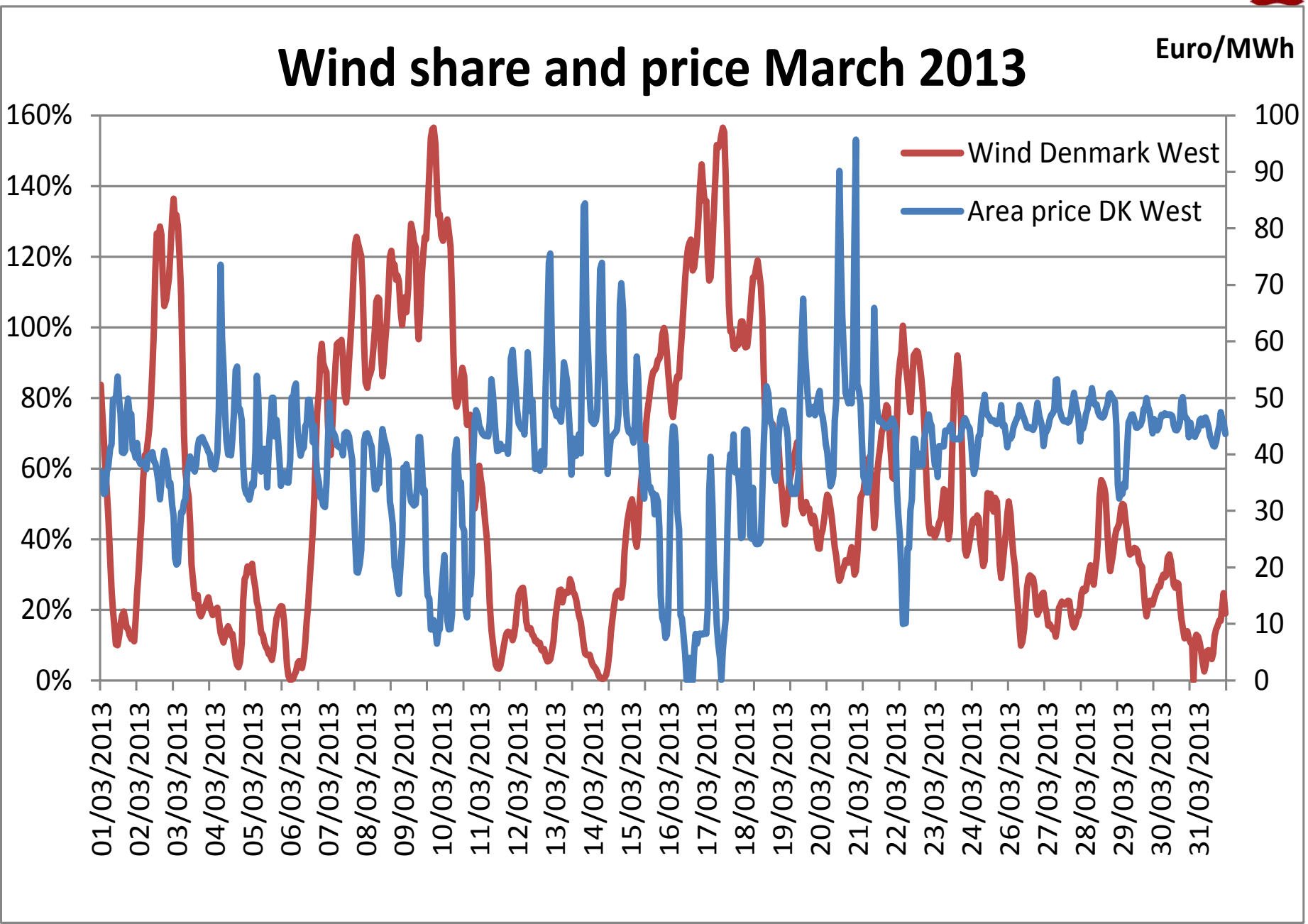
- For the average generator lower prices are unattractive
- For the peak plants this is even less attractive as peak prices are reduced the most and they have the major part of revenue from these hours
- Wind generators (expired support) have a disadvantage to controllable generation as their output is negatively correlated with prices - high output at low price hours

Wind generator revenue

Table 1 Wind generators market based revenues in the Western Denmark price area

	Area Price €/MWh (direct average of hours)	Wind average price €/MWh	Difference €/MWh	Wind price relative to market	Wind generation (GWh)	Potential loss mill. €
2006	44.19	40.54	3.64	92%	4614	16.8
2007	32.40	28.66	3.74	88%	5562	20.8
2008	56.42	51.20	5.22	91%	5190	27.1

Power price is negatively correlated with generation



The long term challenge
How to make investment in conventional technology (back-up/flexibility) profitable with low wholesale prices

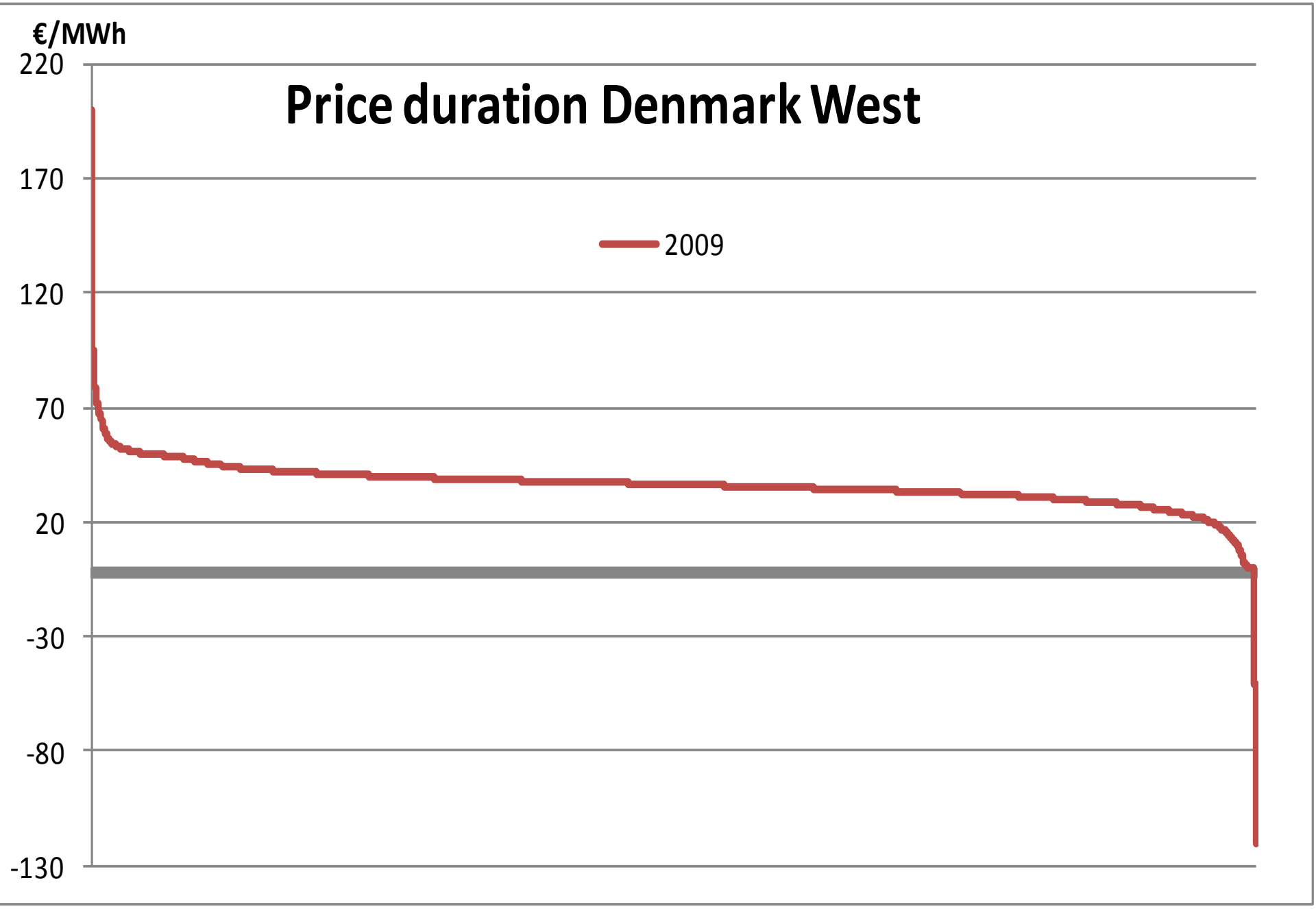
Long term marginal costs

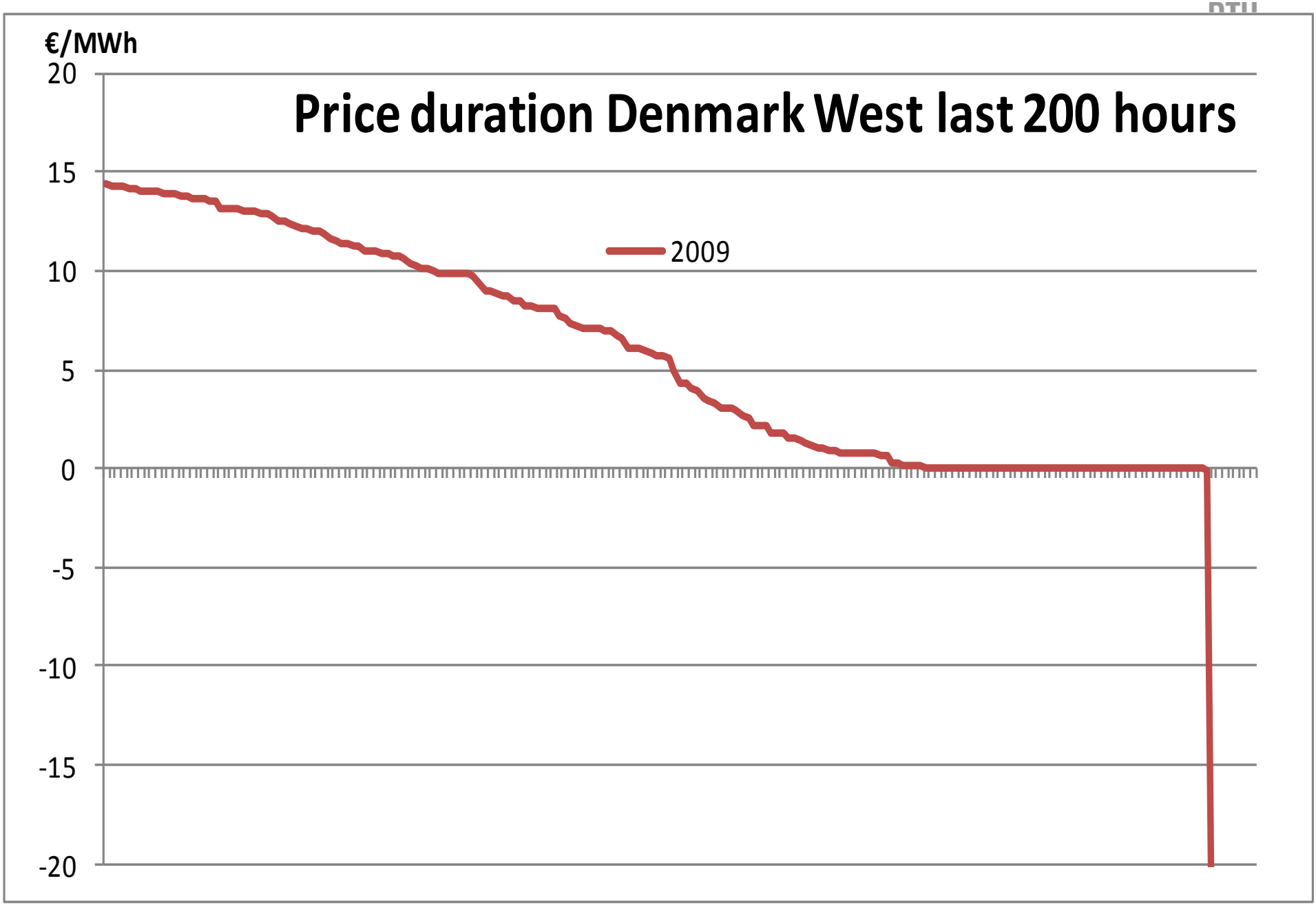
- Intermittent renewable technologies have **low short term** marginal costs *but* **high long term** marginal costs (high investment costs)
- Therefore they require financial support to compete as the preferred investment technology
- The investment in renewables affects the short term power prices downwards
- The investment incentive provided through the short term power markets are thus reduced and
- The conventional capacity will be reduced

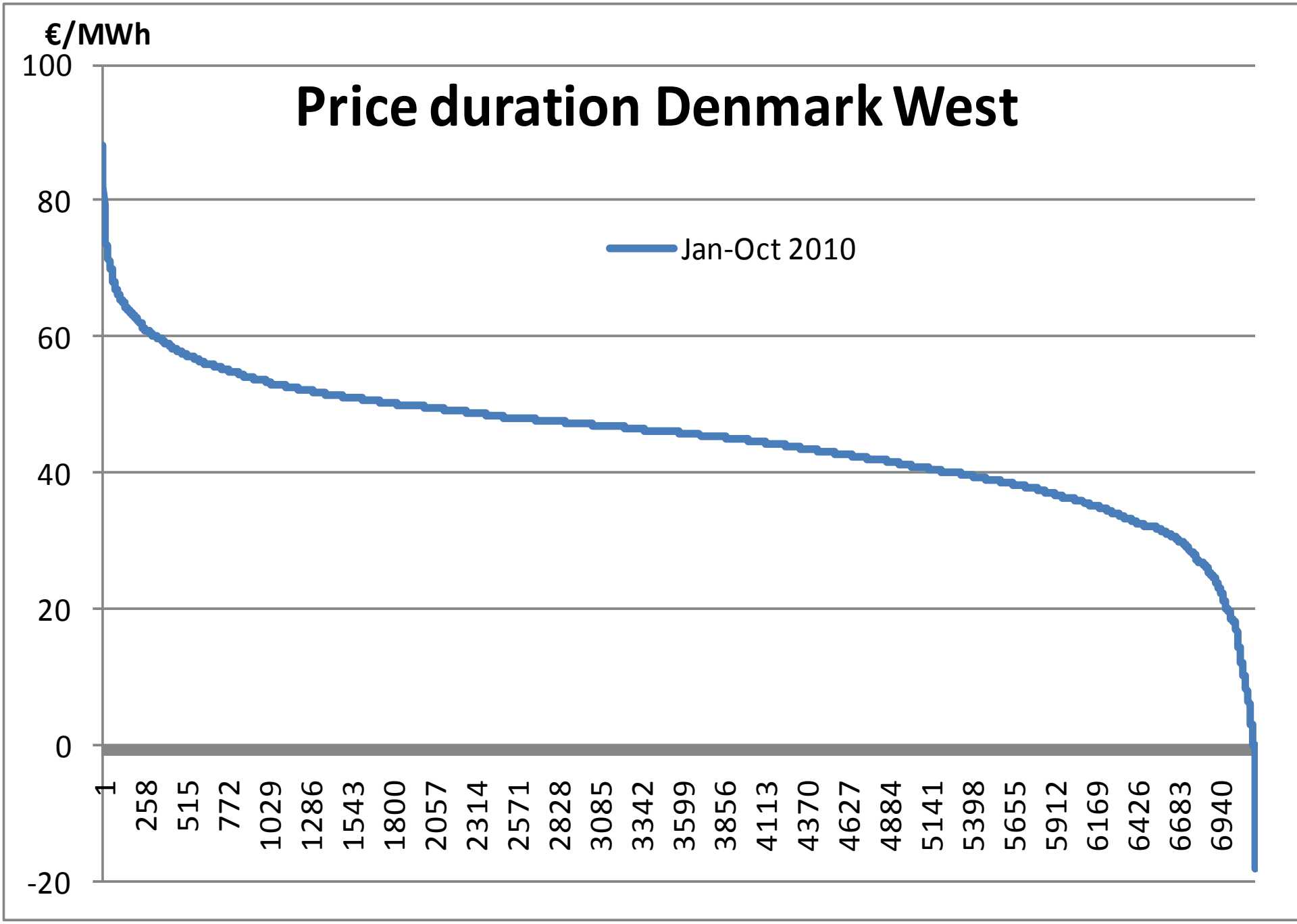
Negative prices

Negative prices for electricity

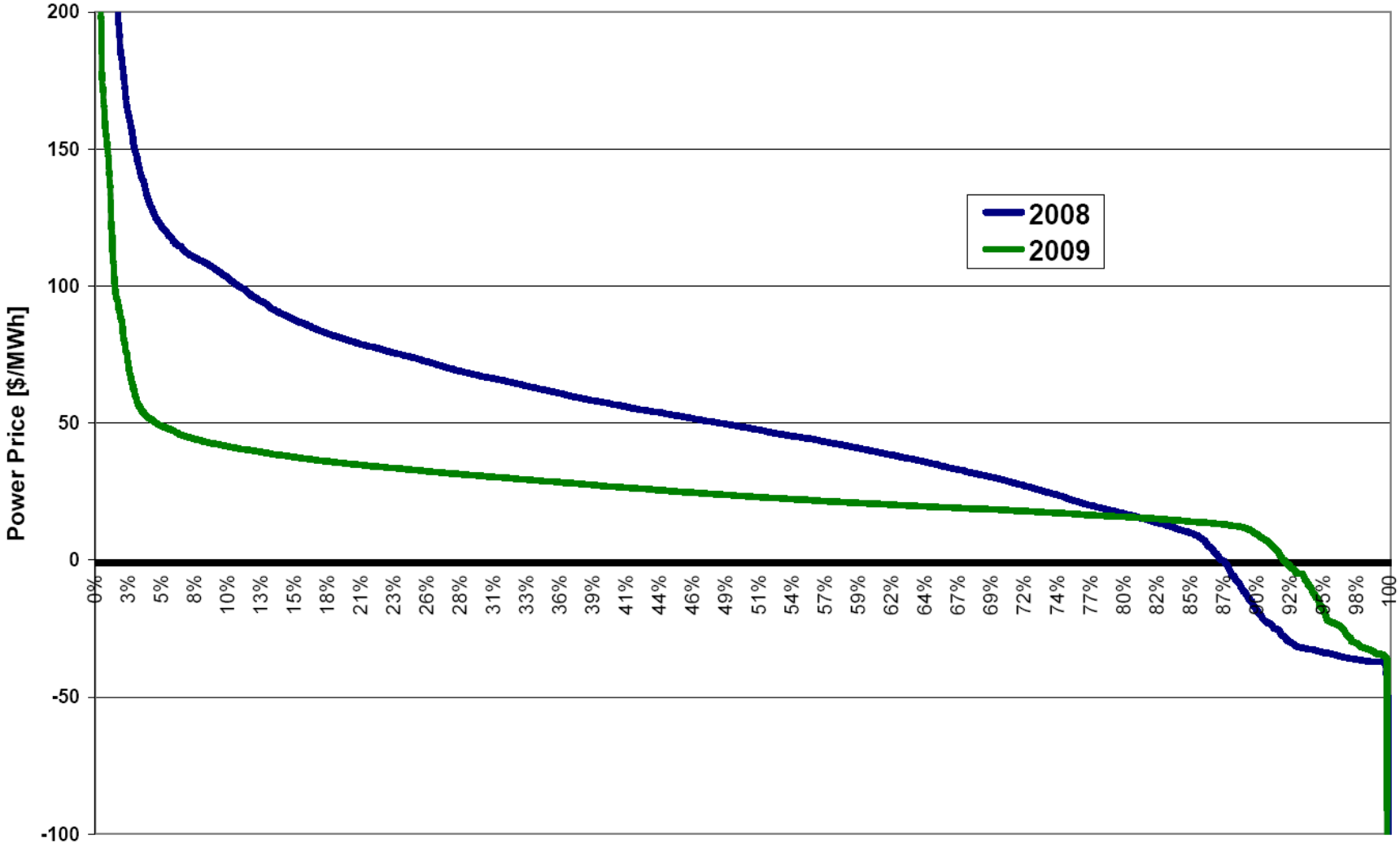
- The marginal value of using more electricity is negative?
- Does not fit with normal assumptions in the long run
- There are good explanations for negative prices in power markets
- Important to allow the negative price signals passed to all generators for efficient allocation of production


€/MWh
220
170
120
70
20
-30
-80
-130
Price duration Denmark West
2009


€/MWh
20
15
10
5
0
-5
-10
-15
-20
Price duration Denmark West last 200 hours
2009


€/MWh
Price duration Denmark West
Jan-Oct 2010
100
80
60
40
20
0
-20
1
258
515
772
1029
1286
1543
1800
2057
2314
2571
2828
3085
3342
3599
3856
4113
4370
4627
4884
5141
5398
5655
5912
6169
6426
6683
6940

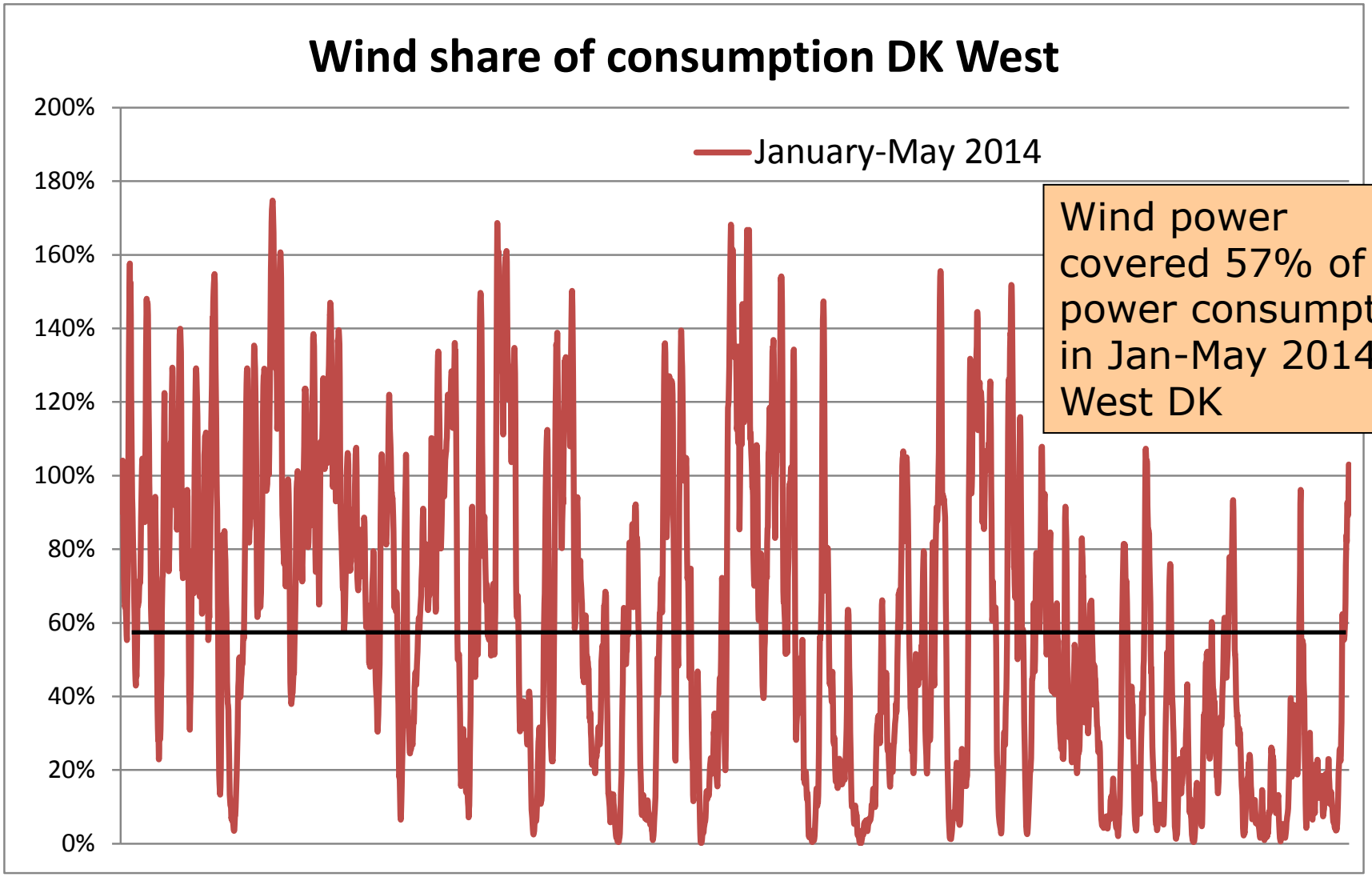
Price duration curves – Texas west



Source: ERCOT (2010)

Negative prices: Explanation and solution

- Stop and start costs for conventional generators (minimum up and down times)
- Renewable generators are subsidised (feed-in tariff or production based tax credits)
- Renewable generation stay online as long as the negative price is less than the support
- Solution:
  - use dynamic tariffs (tax) element of consumer price reduced when zero wholesale price
  - instruct renewables to shut down – involuntarily curtailment
  - reduce/remove the support when power prices are zero or below – voluntary curtailment
- Result: Much less zero and negative prices after a bit of learning


Wind share of consumption DK West
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
January-May 2014
Wind power covered 57% of power consumption in Jan-May 2014 West DK

Thank you for your attention!

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